Practical Application of the Principles of Sterilization

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PRACTICAL APPLICATION OF THE PRINCIPLES OF STERILIZATION.

EVERY surgeon is anxious to discover and carry out any measure which promises to bring about the speedy healing of the wounds which he makes. Since the time that Lister first brought forward his elaborate technique much has been written on the subject of sepsis, asepsis, and antisepsis We must confess, however, that the knowledge of some of the writers did not always equal their zeal, so that their well-meaning efforts, far from helping the cause of which they were such ardent supporters, only produced in the minds of many of their readers a feeling of doubt as to whether any of the procedures advocated were, after all, of much value. For deliverance from this state of uncertainty and doubt we have to thank the bacteriologist.

It is now agreed that in dealing with wounds cleanliness is an absolute necessity, but between ordinary cleanliness and what we term *surgical cleanliness* there is a wide difference. The science of bacteriology has now existed long enough to have rendered many of its discoveries absolutely beyond question, and it is to this science that we must look to decide when we are in the presence of this absolute or surgical cleanliness; and from no other source can we hope for the establishment, on a scientific basis, of a reliable technique to be employed in surgical operations. A knife or a hand may to the naked eye look perfectly clean, and even with the microscope we may be unable to detect the presence of any pathogenic substances; but it is just here that bacteriology comes in and shows us that minute organisms may nevertheless exist upon them which are able to produce severe disease and even death.

The practical, scientific application of an aseptic and antiseptic technique can, then, be thoroughly carried out only by observing every, even the most minute, detail the utility of

which has been proven by bacteriological experiment. In order to become familiar with these details, and in order to appreciate the importance of each at its true value, it would be well if every surgeon could have at least an elementary training in bacteriology. If, however, he has been unable to secure this, it remains for him to accept as his standard of work the principles which have been laid down by those who have had the opportunity of submitting their methods to the test of bacteriological criticism.

Surgical cleanliness can only be insured by sterilization, and it is the object of this paper to show in brief how the principles of sterilization which have, as far as our present knowledge goes, been proved to be the best, may in as simple a form as possible be applied in order to avoid suppuration in wounds and to promote a speedy healing of them. One who has been trained in a bacteriological laboratory cannot fail to see the many inconsistencies that occur during the majority of operations; and while these inconsistencies may to many appear trifling, we have learned that in reality they are only too often responsible for the introduction of infectious material into the wound. Any one who is thoroughly conversant with the conditions which underlie suppuration in wounds and septic processes generally, knows only too well how many are the loopholes for infection; to him it seems remarkable that such cases do not occur more frequently. Though it may be true that every wound made by the surgeon contains micro-organisms, it is probable that under ordinary circumstances the resisting powers of the patient will be sufficient to prevent their growth and development. Experience, however, has taught us that several kinds of bacteria, under certain circumstances, appear to possess sufficient virulence to be capable of setting up violent local or general infection when introduced into the tissues even of a perfectly healthy individual; and although suppuration following an operation is sometimes to be attributed to a lowered systemic resistance on the part of the patient rather than to some fault on the part of the operator, it must be insisted that this is a very rare occurrence, for in nearly every septic case a rigid analysis of the technique employed will bring to light some sin of omission or of commission to account for it. That there are surgeons who do not pay much attention to their technique and yet obtain good results cannot be accepted as a serious argument, and a careful investigation of their

statistics compared with those of aseptic surgeons, if a sufficient number of parallel cases be taken, will certainly show the inferiority of the older methods. In any case it is our duty to our patient to reduce to a minimum the risk which he incurs when submitting to an operation at our hands.

Many bacteria are perfectly harmless to the human organism, others vary very much in their virulence and in their pathogenic properties; and it must be remembered that while, in order to produce infection, the presence of pathogenic bacteria—the "seed"—is necessary, there must always be a suitable "ground" in which they can be reproduced in sufficient numbers to cause serious results. Consequently, while insisting upon the necessity of surgical cleanliness, we do not at all underrate the necessity for skilfulness on the part of the surgeon, and any unnecessary bruising or destruction of the tissues by which their resistance is impaired must be strenuously avoided.

In order to have a condition of surgical cleanliness we must be able, as we have said, to insure the complete absence of pathogenic bacteria; and this can best be brought about by that process which is termed sterilization.

The application of the actual flame in order to destroy infectious material is naturally very much limited, and it is fortunate that we have other agents by the use of which we can attain the same results. Of these we shall discuss (1) heat, (*a*) dry and (*b*) moist, and (2) chemical disinfectants; any or all of these methods may be supplemented by (3) mechanical means—washing, brushing, and the like.

In proceeding to the sterilization of an article all extraneous material is, as far as possible, to be removed by mechanical methods.

Sterilization by fire can be employed for doing away with worthless and dangerous objects, such as soiled dressings and the like; and it would afford a most effectual means for sterilizing instruments, were it not for the fact that they are ruined in the process.

Sterilization by means of dry heat is effective, but unfortunately this agent destroys many substances of vegetable or animal origin. Added to this, dry heat does not permeate the substance to be sterilized nearly so thoroughly as steam heat, and is therefore much more difficult to control. Even in the disinfection of metal instruments it has been supplanted by

more convenient and speedy methods, but it still finds an important application in the sterilization of glassware.

In the sterilization by means of moist heat one of the quickest agents which we possess is boiling water, but by means of an appropriate apparatus steam can also be employed for this purpose.

One of the most ingenious methods of insuring complete disinfection is that known as *fractional* or discontinuous sterilization. The substance to be sterilized is exposed to streaming steam for a certain time on several successive days, so that if after the first day any spores have escaped destruction they are killed by a similar exposure after they have had time to grow into vegetative forms. Tyndall, Pasteur, and others have shown that complete sterilization is practicable with the use of a temperature as low as 60° C., if the process is repeated on three or four successive days.

Steam heat, it is evident, cannot be used for the disinfection of the hands of the operator or the skin of the patient, and certain objects, such as those made of leather or rubber, are destroyed by it.

Antiseptic solutions are still used, but to a more limited extent than formerly and with a greater amount of mental reservation. The ideal chemical disinfectant is as yet undiscovered. It should be easily soluble in water, should possess active germicidal power, and not simply lead to the arrest of the development of bacteria; it should exert a sufficient action within a reasonably short space of time; it should not injure the substances to be disinfected, and should be of such chemical composition that it cannot readily be rendered inert by chemical combination with them; it should not endanger the health of those who handle it, nor possess any very unpleasant odor; and, finally, it must be comparatively inexpensive. Judged by these standards our ordinary chemical disinfectants will all be found wanting. We have no antiseptics of much power which can with impunity be poured into a wound. Carbolic acid, although a powerful antiseptic, is dangerous when used in sufficient strength to exert its germicidal powers. Corrosive sublimate for a long time occupied a unique place in the list of disinfecting agents, among which it was given the pre-eminence by Koch and many others. The experiments by Geppert, however, which have since been confirmed by Abbott in this country, proved that corrosive sub-

limate is not so strong a germicide as was supposed; and Halsted has shown that irrigation of fresh wounds with a solution of bichloride of mercury as weak as one to ten thousand is followed by a distinct line of superficial necrosis, which can easily be demonstrated under the microscope. As an irrigating fluid, then, in the case of fresh wounds, it must be discarded. Other chemical disinfectants, as will be seen when we treat of the methods advised for the practical disinfection of the skin, are of doubtful value; and although we still employ solutions of permanganate of potassium and oxalic acid, we do not allow ourselves to lay too much stress upon their efficiency, considering that they play a very minor part in the process.

Assuming, then, the truth of what bacteriology has taught us —namely, that infection of wounds occurs but rarely through the air, and generally takes place by contact—the end and aim of our surgical technique is to keep far from the field of operation everything which might contain septic germs. In other words, everything which can possibly come in contact with the wound must be sterile. We will now proceed to show how our theories can be practically carried out in the operating room.

Dressings and bandages should be sterilized by steam shortly before each operation. Exposure for three-quarters of an hour to steam at 100° C. serves to render all these substances, if not packed or rolled together too tightly, absolutely sterile. Since bacteria do not multiply on dry substances, it is better to place the dressings, which have been exposed to the steam, in a drying chamber for a short time before applying them. If necessary they can be kept for some time in a closed glass jar previously sterilized.

Tampons and sponges, which are best made of gauze, can be prepared in the same way; they should never be used twice.

The operator and his assistants should be supplied with special suits made of twilled muslin, which have been previously sterilized and allowed to become thoroughly dry. When putting them on, the hands should be allowed to come in contact with the clothing as little as possible. Too much attention cannot be paid to the minor points of personal cleanliness. The hair should be kept short and as free as possible from dandruff. If he can avoid it a surgeon should never operate when he is suffering from coryza or from a catarrh accompanied by mucous

secretions; the handling of a pocket-handkerchief during the operation of course makes a break in the technique.

All suture materials and ligatures should have been previously sterilized. This is best done by cutting them into proper lengths, winding them on reels, and placing them in glass tubes, which are then plugged with cotton and sterilized in the steam sterilizer on two or three successive days.

The operating room should be kept scrupulously clean, the floor being frequently scrubbed with soap and water, and the walls wiped down with a strong solution of bichloride of mercury. The furniture must be submitted to the same process, and any surface upon which any sterile article is to be laid must be covered, for additional safety, with sterilized gauze or towels.

Several methods have been suggested for the sterilization of the instruments, but the most practical and the cheapest is by boiling them in a one-per-cent soda solution. It is the custom to employ for this purpose an ordinary fish kettle, in which the instruments are boiled for five minutes. In order to facilitate the removal of the instruments a flat wire basket with two handles, which fits into the kettle, will be found very convenient. After being lifted from the soda solution they are dumped into a basin containing sterile water which has been prepared for them. Such basins must be previously well scrubbed with soap and water, rinsed off with boiled water, and then filled with a one-to-one-thousand bichloride solution, which is allowed to remain in them for an hour. This is then poured out and the basins are washed out with sterilized water, and, being again filled, are ready for the reception of the instruments.

Many methods have been adopted for the sterilization of the hands. In the light of bacteriological tests which have been applied to the methods usually employed, the following must now be considered to be the most reliable. The operating room suit with the short sleeves having been put on, the hands and forearms are scrubbed vigorously, for ten minutes by the watch, with a stiff brush which has been previously sterilized by steam, and with green soap, the water being used as hot as can be borne and changed at least ten times. In order to avoid any possible contamination from the necessity of turning the spigots on and off with the hands, I have recently had constructed an arrangement by means of which this can be done equally well with the feet. The excess of soap is washed off in hot water, and the

hands and forearms are then immersed in a warm saturated solution of permanganate of potassium, which should be rubbed into the skin with the aid of a sterilized swab. After being washed in a saturated solution of oxalic acid until the stain of permanganate has completely disappeared, they are rinsed off in sterilized lime water and next in sterilized water or sterilized salt solution. Finally they are immersed in a solution of bichloride of mercury (one to five hundred) for two minutes. Just before beginning the operation the hands and forearms are well rinsed in sterilized salt solution to remove any excess of the bichloride. Little or nothing certain can be attained unless each step is conscientiously carried out. An elaborate technique practised in a slipshod manner does more harm than good by deceiving us with a security which is unwarranted. If the hands now be allowed to come in contact with objects which are not sterile the whole work will be undone. The use of sterile rubber gloves to protect the hands after they have been sterilized will often prove of the greatest advantage, for with their aid we can, without much fear of contamination, often perform the needful manipulations about the patient before the operation begins. After she is well arranged and all is ready the gloves are removed, and, the hands having been washed once more in the bichloride solution and again in the salt solution, the operation can be proceeded with.

We will now make a short summary of the steps which are to be taken to render the field of operation practically sterile. Supposing, for the sake of example, that we are dealing with a patient who is to undergo an abdominal section.

1. She should have a daily bath of soap and water, and a vaginal douche of a one-per-cent carbolic-acid solution, for three days before the operation.

2. The hair of the abdomen and pubes should be shaved on the night preceding the day of the operation.

3. The parts are thoroughly scrubbed with:

   a. Soap and water, the brush being used vigorously;

   b. Alcohol and ether to remove the fatty substances;

   c. Bichloride of mercury (one to one thousand).

4. A thin poultice of green soap is applied for from one to three hours, according to the susceptibility of the skin.

5. A compress of bichloride (one to one thousand) is applied and kept on until the patient is brought to the operating table.

After she has been anesthetized and placed upon the operating table the compress is removed and the following additional steps are carried out:

1. The field of operation is scrubbed with soap and warm sterile water.

2. It is sponged with alcohol and ether.

3. In some cases it is washed with solutions of permanganate of potassium and oxalic acid, as in the disinfection of the hands, and subsequently irrigated with warm sterile water or salt solution.

4. It is irrigated with one litre of a solution of bichloride of mercury (one to one thousand).

5. It is irrigated with sterilized salt solution to remove any excess of sublimate.

Of the rules for diet it is not necessary to speak here.

We should aim at as thorough an aseptic technique in plastic work as in abdominal surgery. In the majority of instances, it is true, errors in technique are not so often associated in these so-called minor operations with disastrous consequences as when the same errors have been committed in abdominal sections. Yet there are many instances on record of deaths from sepsis following upon a simple plastic operation, and could we properly analyze the list of cases in which the cause of death has been attributed to pneumonia, to lesions of the kidneys or other organs, their number would undoubtedly be much augmented. In not a few obscure cases in which death had followed a plastic operation a thorough autopsy, together with a careful bacteriological examination, has demonstrated that death was due to an infection with pyogenic bacteria. Many of the deaths which we have been inclined to regard as due to acute nephritis are now known to have been caused by infection with associated acute lesions of the kidneys. The following case is, I think, worthy of mention in this connection. A woman, 58 years of age, six weeks after a perineorrhaphy gradually developed symptoms suggestive of nephritis. The examination of the urine showed the presence of albumin and of granular and hyaline casts. She gradually grew worse, and died a week later in coma. At the autopsy minute abscesses were found in the heart muscle, in the liver, spleen, kidney, and intestines, and agar-agar Esmarch tubes made from these organs gave in every case a pure culture of the staphylococcus pyogenes aureus. The portal of entrance

was found to have been the deep perineal tissues, where, just beneath the line of the wound, small foci of pus were found.

Although it is often more difficult to render the field of operation thoroughly clean and to keep it so, during these minor operations, than when we are dealing with an abdominal case, these facts teach us that the attempt must always be made. We will therefore summarize the procedures which seem to be the most efficient. On the previous evening the parts are carefully shaved and scrubbed with soap and water, washed off with sterile water and afterward with a one-to-one-thousand solution of the bichloride of mercury. After the patient has been placed upon the operating table the vagina, perineum, and external genitalia are to be thoroughly scrubbed with oleine soap and sterilized distilled water. This should take at least from three to five minutes, a liberal supply of soap being used and being well rubbed into the skin. In order to cleanse the vagina a small oblong piece of soap is taken and introduced into the cavity, and the suds are rubbed thoroughly into the walls; or a large piece of absorbent cotton, held with the sponge-holder or bullet forceps, can be used as a swab. The excess of soap having been washed off with warm sterile water, the external parts are rinsed with a litre of a warm aqueous solution of bichloride of mercury (one to one thousand) and finally with sterilized water or salt solution. If there are large, protruding hemorrhoids, and a considerable surface of the rectal mucous membrane is exposed, the bichloride of mercury must be used with caution, as sufficient may be absorbed to give rise to toxic effects. Under these circumstances it is well to wash out the rectum with a solution of permanganate of potassium (one to one thousand) morning and evening for two days before the operation, while on the morning of the operation soap and water only are employed and the parts are finally rinsed off with sterilized water.

Fluids for irrigation, dusting powders, and the various kinds of celloidin used in dressings, all must be sterile.

It would be impossible now to go into a detailed account of all the possible emergencies which may arise, and which, if they are not properly met, may nullify in a moment all our previous efforts. Sufficient has, I hope, been said to show on what principles every detail of our technique must be based; and if a surgeon has once learned to recognize hard-and-fast laws which tell him what he may or may not do, we can trust to his common

sense to successfully overcome all difficulties which may present themselves. We are still in a stage of transition, our surgical technique is not yet perfect, but at least we may feel assured that we are starting out with right principles, by following which we may finally approach the end at which we are aiming, namely, perfect asepsis.

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